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(71) Applicant: **TEXAS INSTRUMENTS INCORPORATED**
13500 North Central Expressway
Dallas Texas 75265(US)
(84) **BE CH DE DK ES FR GB GR IT LI LU MC PT SE AT**

(71) Applicant: **Texas Instruments Holland B.V.**
Kolthofsingel 8 Postbox 43
NL-7600 AA Almelo(NL)
(84) **NL**

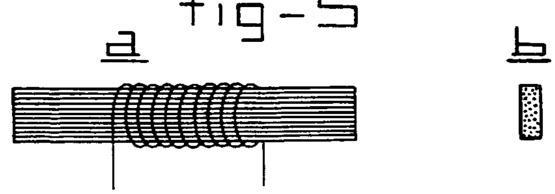
(72) Inventor: **D'Hont, Loek J.**
De Notenkraker 2
NL-7609 AK Almelo(NL)

(74) Representative: **de Bruijn, Leendert C. et al**
Nederlandsch Octrooibureau
Scheveningseweg 82 P.O. Box 29720
NL-2502 LS Den Haag (NL)

(54) **Method for producing a flat flexible antenna core for a chip transponder to be incorporated in a badge or similar object, and a thus produced antenna core.**

(57) An antenna core is of a material having a high quality factor, wherein an elongated strip of mutually insulated, longitudinally stretched chains of magnetic soft material of high μ is formed. In one aspect a powder of small particles of a magnetic soft material of high μ is mixed with a synthetic resin so that a high saturation of magnetic material in the mixture is formed in a vacuum. The mixture is cured in the shape of a block while being in a strong static magnetic field and the particles form persistent chains parallel to the applied magnetic field. The block is cut into thin strips following a longitudinal direction which corresponds to the direction of the previously applied magnetic field, each such strip making up an antenna core. In another aspect said chains are formed of thin wires of magnetic soft iron covered with an insulating layer. These wires are formed into a flat bundle-shaped strip, such strip making up an antenna core. In yet another aspect said elongated strips are formed of an amorphous alloy, in which the longitudinal direction coincides with the direction of magnetic field, said strips being mutually insulated. A stack is formed of one or more of these strips, such stack making up an antenna core. A flat flexible antenna is obtained by forming an electrical winding around one or more of the above mentioned strip- or stack-shaped antenna cores.

fig-5



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Field of the Invention

The invention relates to a method for producing a flexible magnetic antenna core for a chip transponder to be incorporated in a badge or similar object, which antenna core is of a material with a high quality factor and low magnetic losses.

Backgr und of the Invention

In the art of identifying objects or animals, increasing use is recently being made of chip transponders having an associated small antenna. Recently chip transponders have come into use which are placed in a badge, card or similar flexible sheet. An antenna for use in this application must in general have a flat and flexible magnetic core around which the antenna winding may be fitted, and yet have a high quality factor to provide specific antenna characteristics. The ferrite elements which have been used in the past are relatively hard and insufficiently flexible so that consequently, they will break when bent.

Summary of the Invention

It is an object of this invention to provide a method for producing such a flexible magnetic antenna core which has low losses and a sufficiently high quality factor in order to provide the required antenna radiation characteristics.

This is achieved in a method according to the invention as indicated above such that as a magnetic antenna core, an elongated strip of mutually insulated, longitudinally stretched chains of magnetic soft material of high μ is formed.

In one aspect, the method involves forming said chains of thin wires made of magnetic soft iron and covered with an insulating layer and forming these wires into a flat bundle or strip. Around this strip-shaped core, an electrical winding is formed.

In another aspect the method involves forming said chains of thin strips made of amorphous alloy and covered by an insulating layer. Around a single such strip or a plurality of stacked such strips an electrical winding is then formed.

In yet another aspect, the method involves forming a powder form small particles of magnetic soft material of high μ, mixing this powder with a synthetic resin so that a high saturation of magnetic material in the mixture is obtained in a vacuum, and that the mixture is allowed to cure in block-shaped form while being exposed to a strong static magnetic field which causes particles to form chains which will remain parallel to the applied magnetic field. From the block, and in parallel with the chain direction, flat strips will subsequently be cut.

Brief Description of the Drawings

Some embodiments of the invention will now be explained in more detail referring to the drawings, in which:

Figure 1 shows a view in perspective of a block of metal in which the orientation of the H-field and eddy currents are indicated;

Figure 2a is a diagrammatic view of a device for curing a mixture of powder of magnetic soft material and synthetic resin while being in a strong magnetic field;

Figure 2b shows a front view of a block of such a mixture placed in such a static field;

Figure 3 shows a view in perspective of a strip-shaped antenna core cut from the block of Figure 2b in a longitudinal direction and fitted with an electrical winding, as a first embodiment of the invention;

Figure 4 shows a view of a single thin wire of magnetic soft iron which has an insulating layer;

Figures 5a and 5b respectively show a plan view and a cross-sectional view of a flat bundle-shaped strip of a number of wires of Figure 5; which represents an antenna core fitted with an electrical embodiment according to the invention;

Figure 6 shows a view in perspective of such a strip-shaped antenna core, as indicated in Figure 5, with the H-field and without eddy currents;

Figure 7 shows a view of a stacked number of strips of amorphous alloy which represents a variant of the antenna core of Figure 6; and

Figures 8a to 8c show examples of the interconnection of the strips in the stack of Figure 7.

Description of the Preferred Embodiments

In producing a flat and flexible antenna core, one will preferably attempt to produce a basic strip of chains of magnetic soft material of high μ around which the electrical winding is to be wound. With such a strip it is a problem that the magnetic properties of the chains with the highest permeability are effected by the distance between the magnetic particles in each chain parallel to the longitudinal axis of the magnetic inductor. For a good magnetic conduction, that is for optimized magnetic antenna characteristics, it is required that the magnetic particles are arranged with the smallest possible spacing between each other. Another requirement is, that transverse to the longitudinal direction of the strip axis, there needs to be a distance between particles so that they will not be in electrical contact with each other. Thereby eddy currents, which otherwise would form in the material during use as an antenna, will be limited to a

minimum so that the antenna losses are low or the quality factor is high. In Figure 1, an example is given of a fixed metal core which, if used for an antenna, would give rise to eddy currents. These eddy currents develop at right angles to the H-field and will therefore cause considerable losses and a low quality factor. Therefore, an optimum antenna design has within the strip, magnetic particles arranged with the smallest possible spacing between each other in the longitudinal direction of the strip axis, and insulation between the strips, perpendicular to the longitudinal direction of the strip axis.

In one aspect of the method according to the invention, a powder of small particles of ferrite or another magnetic soft iron material of high μ is formed. This powder is mixed with a synthetic resin so that a high saturation of magnetic material in the mixture is obtained. The mixing is performed in a vacuum in order to avoid the presence of air cavities in the material after curing.

In order to obtain a mixture in which the magnetic particles in the longitudinal direction of the particles are as close together as possible, the mixture is cured while being in a strong static magnetic field. This is performed in a device as indicated in Figure 2a. By applying a strong static magnetic field, the magnetic particles in the mixture are arranged end to end in chains, parallel to the H-field lines. After curing, the field is removed and the chains which were formed in parallel to the previously applied field remain. Next, the resulting block is cut into strips following a direction of cutting which is parallel to the direction of the previously applied H-field, as indicated in Figure 2b. Finally, flat strip-shaped cores of cured soft magnetic material of high μ are obtained as indicated in Figure 3. Around each strip, an electrical winding is formed.

In another aspect of the method according to the invention, an elongated strip-shaped core is formed of thin wires h of soft magnetic iron and covered with an insulating layer 1, each of which wires form a chain as described above. Figure 4 shows such an insulated wire. Subsequently, a number of these wires is formed into a flat bundle-shaped strip of which Figure 5a and 5b, respectively, provide a plan view and a cross-sectional view. This cross-sectional view shows in outline in what manner the wires in this strip are stacked beside each other and in top of each other. Around the strip-shaped core an electrical winding is formed as described above.

In Figure 6, a view comparable to that of Figure 1 is provided of the flat strip of Figure 5 with the orientation of the H-field, which indicates that no more eddy currents occur.

With a variant of the strip-shaped antenna core of Figure 5 as indicated in Figure 7, thin insulated strips of amorphous alloy are used as the magnetic core instead of wires of soft iron covered with an insulating layer. The reasons for using this alloy are the relatively low induction losses with higher operational frequencies as compared to those of soft iron, a good mechanical flexibility and resistance against bending, a high initial magnetic permeability, and the fact that the magnetic properties are not effected by mechanical stress.

The high initial permeability factor of the alloy results in a very stable effective permeability of the rod in the eventual antenna application. Because of the high permeability, the effective or "rod" permeability in the antenna application will only depend on mechanical core tolerances. Thereby any variation in permeability, caused by badge variables in the production of the alloy or dependency on operational temperatures, are eliminated. Another useful characteristic of this amorphous alloy is its high stability of magnetic parameters when subjected to mechanical forces such as bending. This stability is considerably better in comparison with that of other magnetic materials. The aforementioned characteristics of the material will provide a flat transponder antenna with characteristics that meet the practical requirements in a considerable degree and also provide very good reproducibility for mass production.

In Figure 7, a perspective view is provided of some stacks of thin insulated layers of an amorphous alloy. During this stacking and alignment, the proper orientation of one amorphous strip to another needs to be maintained because the magnetic properties of this material are sensitive to the "magnetic" orientation of field as indicated in Figure 7. In addition, as with the individual wires of the antenna core, the strip-shaped layers in Figure 7 in a single stack and in adjacent stacks are electrically insulated from each other in order to prevent magnetic core losses resulting from eddy currents. These eddy currents are normally perpendicular to the H-field, as indicated in Figure 1, and the insulation between the layers will reduce these eddy currents. Therefore, a combination of strips of amorphous metals, parallel to each other as with the embodiment with metal fibers or wires, may be used whereby the eddy currents will be reduced even further.

For example, if the insulated strips of amorphous alloy are 50mm long, 20µm thick and 12mm wide, and are stacked such that the stack is still 50mm long and 12mm wide but greater than 20µm thick, the resultant core displays a rather low quality performance and is lossy. If, however, the width of the strip is cut from 12mm to 2 or 3mm, the quality performance of the core is enhanced greatly. Furthermore, the more narrow the strips, the higher the quality performance. This phenomena

supports the abovementioned principle which states that to maintain eddy currents at a minimum, the strips must not be wide in the transverse direction, perpendicular to the longitudinal direction of the strip axis, which would facilitate the rise of eddy currents. Rather, thousands of individual insulat d amorphous fibers formed into a flat bundle-shaped strip as is shown in Figure 5a with wires, would be an optimum flexible antenna design.

The insulation between the strips of one stack may be realized by placing thin, foil-shaped, non-conducting materials, such as plastics, between the amorphous layers. Also, one surface on one side of the alloy strip may be treated chemically, for example oxidized, so that they become highly resistant to electric current and provide a barrier for eddy currents which are induced in the cross section of the core, perpendicular to the H-field. The insulation between the adjacent stacks may be realized by maintaining some spacing between these stacks.

The strips also need to be stacked in a special way so that the entire package will not lose its flexibility, neither longitudinally nor in its transverse direction, as, for example, is indicated in Figure 8. Figure 8a provides in outline a side view of four strips, stacked on top of each other, and of the way in which in the middle area "d" of the strips are mechanically attached to each other so that the ends may move freely with respect to each other. Figure 8b provides in outline a top view of three adjacent and mutually insulated stacks of strips, which stacks in the middle area "e", on the upper and lower side, are attached to each other. In dependence of the application, one or more adjacent stacks (i.e. like three stacks in Figure 8b) are used. Around the whole a winding is wound. In Figure 8c it is indicated how these ends "g" may move with respect to each other and thereby ensure the flexibility of the strip-shaped core. During this movement, the middle area "f" maintains its position. For linking together the central areas of the strips an adhesive may be used or linking techniques such as point welding or ultrasonic welding. As long as the area of the point or area linkage remains small, the increase of the eddy currents in this area in cross section will be marginal.

Advantageously, the method described above provides a flat and flexible antenna which has a high quality factor and is very suitable for application as an antenna for a transponder in, for example, a badge or credit card or a similar object.

Claims

1. Method for producing a flexible magnetic antenna core for a chip transponder to be incorporated in a badge or similar object, which antenna core is of a material having a high quality factor, wherein an elongated strip of mutually insulated, longitudinally stretched chains of magnetic soft material of high μ is formed.

2. Method according to claim 1, wherein a powder of small particles of a magnetic soft material of high μ is formed, that this powder is mixed with a synthetic resin so that a high saturation of magnetic material in the mixture is formed in a vacuum, and that the mixture is cured in the shape of a block while being in a strong static magnetic field, whereby the particles form persistent chains parallel to the applied magnetic field.

3. Method according to claim 2, wherein the block is cut into thin strips following a longitudinal direction which corresponds to the direction of the previously applied magnetic field, each such strip making up an antenna core.

4. Flat flexible antenna obtained by forming an electrical winding around the strip-shaped antenna core of claim 3.

5. Method according to claim 1, wherein the said chains are formed of thin wires of magnetic soft iron covered with an insulating layer, and that these wires are formed into a flat bundle-shaped strip, such strip making up an antenna core.

6. Flat flexible antenna obtained by forming an electrical winding around the strip-shaped antenna core of claim 5.

7. Method according to claim 1, wherein the said elongated strips are formed of an amorphous alloy, in which the longitudinal direction coincides with the direction of magnetic field, said strips being mutually insulated, and that a stack is formed of one or more of these strips, such stack making up an antenna core.

8. Flat flexible antenna obtained by forming an electrical winding around one or more of the stack-shaped antenna cores of claim 7.

9. Method according to claim 7, wherein said elongated strips are 3mm in width.

10. Method according to claim 7, wherein said elongated strips are amorphous fibers.

11. Flat flexible antenna according to any of the claims 4, 6 and 8 for use in a chip transponder to be incorporated in a badge or similar object.

fig-1

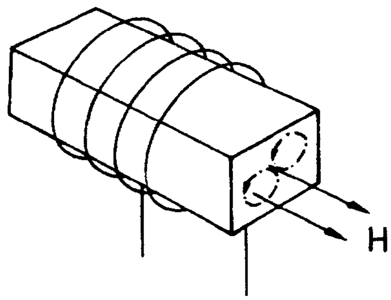
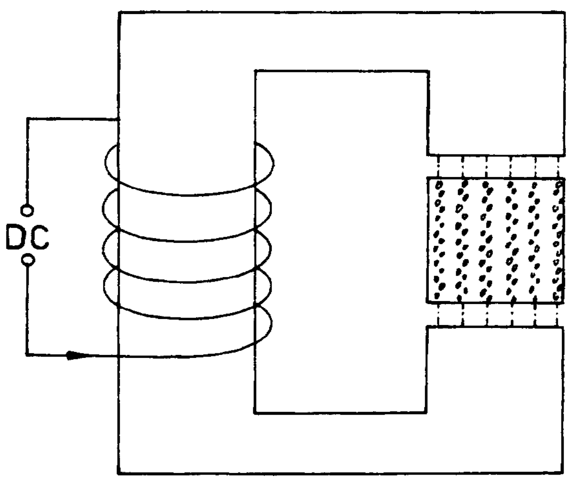


fig-2

a



b

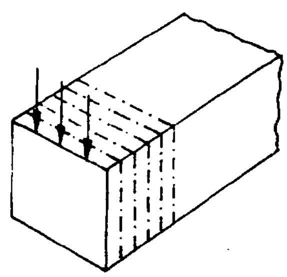


fig-3

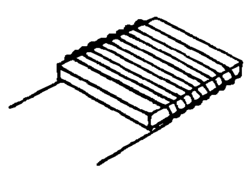


Fig-4

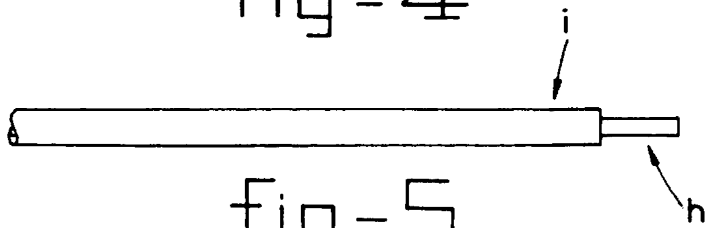


Fig-5

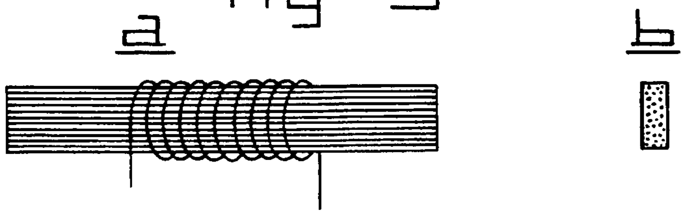


Fig-6

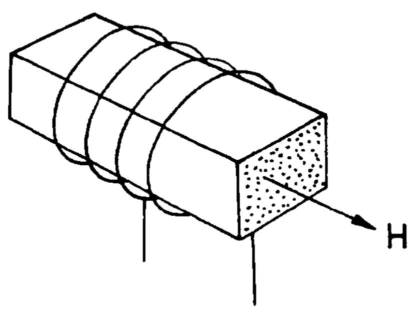


Fig-7

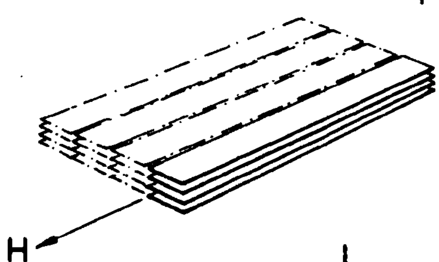
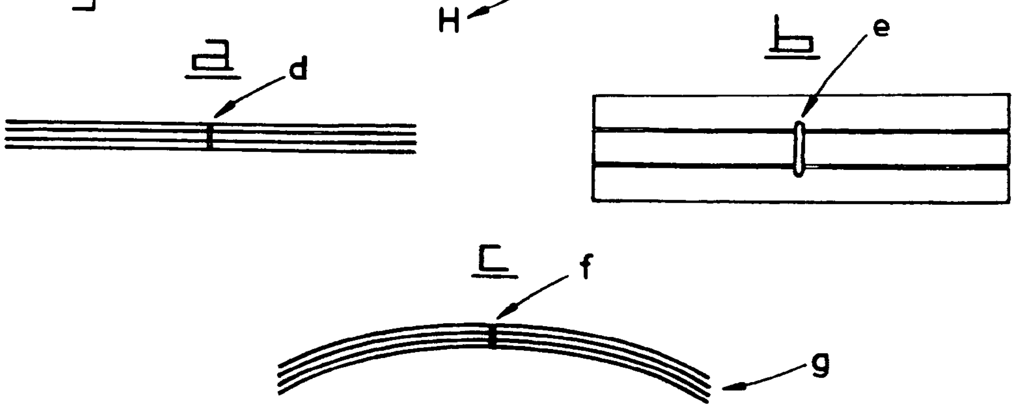


Fig-8



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EUROPEAN SEARCH REPORT

Application Number

EP 92 20 0331

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	EP-A-0 348 636 (JUNGHANS) * column 3, line 58 - column 5, line 32; figure 1 * ---	1,7,8	H01Q7/06
X	PATENT ABSTRACTS OF JAPAN vol. 10, no. 91 (E-394)(2148) 9 April 1986 & JP-A-60 233 904 (MATSUSHITA) 20 November 1985 * abstract * ---	1,7,8	
A	PATENT ABSTRACTS OF JAPAN vol. 4, no. 40 (E-4)(522) 28 March 1980 & JP-A-55 011 669 (TOKYO DENKI KAGAKU KOGYO) 26 January 1980 * abstract * ---	1,2	
A	US-A-4 458 248 (LYASKO) * column 3, line 4 - line 49; figures 1,2 * ---	1,5,6	
A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 362 (E-663)(3209) 28 September 1988 & JP-A-63 115 403 (MATSUSHITA) 20 May 1988 * abstract * ---	1,4	TECHNICAL FIELDS SEARCHED (Int. Cl.5) H01Q G06K G04G G01S
A	EP-A-0 301 127 (TEXAS INSTRUMENTS) * column 15, line 48 - column 16, line 17; figures 4,5 * -----	1,11	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 AUGUST 1992	ANGRABEIT F.F.K.

CATEGORY OF CITED DOCUMENTS

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